

Chapter 2

Operational Risk

Abstract In this Chapter an overview of the operational risk is provided. Operational risk is the most popular topic among the finance and banking professionals. It generally results from the loss arising from inadequate or failed processes, people or systems or from external events. It has also attracted the attention of academic research community. This Chapter contains the basic fundamental ideas of operational risk as stipulated through the Basel regulatory framework. The Chapter forms the basic building block for the entire research monograph. The operational risk data can be either internal or external in nature which is often used in the quantification of operational risk.

Keywords Operational risk • Finance • Banking • Basel • Quantification

2.1 Introduction

The topic of operational risk has gained increasing attention in both academic research and in practice. In this Chapter we have collected together the basic ideas of operational risk needed for a better understanding of the book. A general view of operational risk is given in Sect. 2.2. In Sect. 2.3 a discussion of regulatory framework on operational risk is highlighted as coined by Basel I, II and III. This is followed by the operational risk internal and external data in Sect. 2.4. In Sect. 2.5 we present a method to quantify operational risk. Any reader familiar with operational risk may directly proceed to Sect. 2.5. A good general reference for operational risk and its quantification is [12].

2.2 Operational Risk: A General View

Operational risk [1, 10] is the risk of loss resulting from inadequate or failed processes, people or systems or from external events. It is an important risk component for financial institutions and banks [9] as evident by large sums of capital that are allocated to mitigate this risk. This risk is delicately placed between credit and market risk. It is usually estimated between 15 and 25 % of total risk and deserves serious attention. According to Basel Committee operational risk can be defined as:

Operational risk is the risk of direct or indirect loss resulting from inadequate or failed internal process, people or systems or from external events.

The operational risk could be disaster risk, fraud risk, technological risk or litigation risk. Since the beginning of 1970s, Black and Scholes [2] have shown how to dynamically hedge market risk using derivatives. Later, the introduction of credit derivatives opened the way to hedge credit risk at the end of 1980s. The first recommendations of Basel Committee was not concerned with operational risk, considering implicitly that hedging two other risks covers automatically the third one [3]. The need of an effective risk management and measurement system for operational risk only appears during the revision process of Basel I with first explicit call of a minimum capital charge devoted to risk at the beginning of 2000. The allocation of capital that bank keeps as reserves for potential operational losses remains the only way to cover operational risk. This means that it is not really dynamic or active hedging strategy as it can for two other risks.

The Basel Committee [4] proposed to encompass explicitly risks other than credit and market in the New Basel Capital Accord. The Committee made the New Basel Capital Accord more risk sensitive with the realization that risks other than credit and market are substantial. Further it developed banking practices such as securitization, outsourcing, specialized processing operations and reliance on rapidly evolving technology and complex financial products and strategies suggested that these other risks were increasingly important factors to be reflected in credible capital assessments by both supervisors and banks.

Under the 1988 Accord the Basel Committee [4] recognized that the capital buffer related to credit risk implicitly covered other risks. The broad brush approach in the 1988 Accord delivered an overall cushion of capital for both the measured risks viz. credit and market and other unmeasured banking risks. The new requirements for measured risks were a closer approximation to the actual level of those risks less a buffer that exists for other risks. It was also noted that banks themselves typically hold capital well in excess of the current regulatory minimum and some were already allocating economic capital for other risks.

The Basel Committee [4] believed that a capital charge for other risks included a range of approaches to accommodate the variations in industry risk measurement and management practices. Through extensive industry discussions the Committee learned that measurement techniques for operational risk and a subset of other risks

remain in an early development stage at most institutions. As additional aspects of other risks remained very difficult to measure, the Committee focused the capital charge on operational risk and offered a range of approaches for assessing capital against this risk.

The Basel Committee's [4] goal was to develop methodologies that increasingly reflected an individual bank's particular risk profile. The Basic Indicator Approach linked the capital charge for operational risk to a single risk indicator such as gross income for the whole bank. The Standardized Approach was more complex variant of the Basic Indicator Approach that used a combination of financial indicators and institutional business lines to determine the capital charge. Both approaches were predetermined by regulators. The Internal Measurement Approach strived to incorporate within a supervisory specified framework, an individual bank's internal loss data into the calculation of its required capital. Like the Standardized Approach the Internal Measurement Approach demanded a decomposition of the bank's activities into specified business lines. However, the Internal Measurement Approach allowed the capital charge to be driven by banks' own operational loss experiences within a supervisory assessment framework. In future a Loss Distribution Approach in which the bank specified its own loss distributions, business lines and risk types were available.

An institution's ability to meet specific criteria determined the framework used for its regulatory operational risk capital calculation. The Basel Committee's [4] intention was to calibrate the spectrum of approaches so that the capital charge for a typical bank were less at each progressive step on the spectrum. This was consistent with the Committee's belief that increasing the levels of sophistication of risk management and precision of measurement methodology should be rewarded with a reduction in the regulatory operational risk capital requirement.

The Basel Committee [4] wanted to enhance operational risk assessment efforts by encouraging the industry to develop methodologies and collect data related to managing operational risk. Consequently the focus was primarily upon the operational risk component of other risks and it encouraged the industry to further develop techniques for measuring, monitoring and mitigating operational risk. In framing the proposals the Committee adopted a common industry definition of operational risk as defined earlier. The strategic and reputational risk was not included in this definition for the purpose of a minimum regulatory operational risk capital charge. This definition focused on the causes of operational risk and the Committee believed that this was appropriate for both risk management and measurement. However, in reviewing the progress of the industry in the measurement of operational risk the Committee was aware that causal measurement and modelling of operational risk remained at the earliest stages. For this reason the Committee rolled out further details on the effects of operational losses in terms of loss types to allow data collection and measurement to commence.

As stated in the definition of operational risk the Basel Committee [4] intends for the capital framework to shield institutions from both direct and certain indirect losses. At this stage the Committee was unable to prescribe finally the scope of the charge in this respect. However, it was intended that the costs to fix an operational

risk problem, payments to third parties and write downs generally would be included in calculating the loss incurred from the operational risk event. Furthermore there were other types of losses or events which should be reflected in the charge such as near misses, latent losses or contingent losses. The costs of improvement in controls, preventative action and quality assurance and investment in new systems were not included.

In practice such distinctions were difficult as there existed a high degree of ambiguity inherent in the process of categorizing losses and costs which may result in omission or double counting problems. The Basel Committee [4] was cognizant of the difficulties in determining the scope of the charge and looked for comments on how to better specify the loss types for inclusion in a more refined definition of operational risk. Further it was likely that detailed guidance on loss categorization and allocation of losses by risk type need to be produced. This allowed the development of more advanced approaches to operational risk and the Committee also looked for detailed comments in this respect.

In line with other banking risks [4] conceptually a capital charge for operational risk covered unexpected losses due to the risk involved. Provisions also covered the expected losses. However, accounting rules in many countries do not allow a robust, comprehensive and clear approach to setting provisions. Rather these rules appeared to allow for provisions only for future obligations related to events that have already occurred. In particular accounting standards generally required measurable estimation tests to be met and losses to be probable before provisions or contingencies were actually booked. In general provisions set up under such accounting standards bear only a very small relation to the concept of expected operational losses. Regulators were interested in a more forward looking provisions' concept.

There were cases where contingent reserves may be provided that relate to operational risk matters. An example being the costs related to lawsuits arising from a control breakdown. Also there were certain types of high frequency or low severity losses such as those related to credit card fraud that appear to be deducted from the income as they occur. However, provisions were generally not set up in advance for these. The current practice for pricing for operational risk varies widely. Regardless of actual practice it was conceptually unclear that pricing alone was sufficient to deal with operational losses in the absence of effective reserving policies.

The situation may be somewhat different for banking activities that have a highly likely incidence of expected, regular operational risk losses that were deducted from reported income in the year such as fraud losses in credit card books. In these limited cases it might be appropriate to calibrate the capital charge to unexpected losses or unexpected losses plus some cushion of imprecision. This approach assumes that the bank's income stream for the year would be sufficient to cover expected losses and that the bank can be relied upon to regularly deduct losses.

Against this background the Basel Committee [4] proposed to calibrate the capital charge for operational risk based on expected and unexpected losses, but to allow some recognition for provisioning and loss deduction. A portion of end of

period balances for specific list of identified types of provisions or contingencies could be deducted from the minimum capital requirement provided the bank disclosed them as such. Since capital was a forward looking concept the Committee believed that only part of a provision or contingency should be recognized as reducing the capital requirement. The capital charge for a limited list of banking activities where the annual deduction of actual operational losses was prevalent could be based on unexpected losses only plus a cushion for imprecision. The feasibility and desirability of recognizing provisions and loss deduction depend on there being a reasonable degree of clarity and comparability of approaches to defining acceptable provisions and contingencies among countries. The industry was invited to comment on how such a regime might be implemented.

In June 2004 Basel II [4] was published which was intended to create an international standard for banking regulators to control how much capital banks need to put aside to guard against the financial and operational risks banks face. It has forced banks to give more direct attention to risks that outsiders might first think of. It is agreed that while credit, market and insurance risks are relatively tractable as methodology and availability of necessary data that is not the case for operational risk. Table 2.1 shows a number of kinds of operational risk along with some examples of where those risks have been realized and some applicable methodologies. The table also includes a few risks that are not classified as operational risk under Basel II.

The Basel II Capital Accord [4] stipulates the bank's capital adequacy requirements. This accord requires operational risk to be measured and controlled separately from market risk and credit risk. The advanced measurement approach (AMA) [3] uses the most sophisticated risk management methodologies and allows banks to use their own internal model for calculating operational risk as there is no standard measurement method has been established. Figure 2.1 represents a trivial method which is often used by the financial institutions to measure operational risk.

All three pillars of the New Basel Capital Accord viz. minimum capital requirements, the supervisory review process and market discipline play an important role in the operational risk capital framework. The Basel Committee regulated a Pillar 1 minimum capital requirement and a series of qualitative and quantitative requirements for risk measurement which was used to determine eligibility to use a particular capital assessment technique. The Committee believed that a rigorous control environment was essential to prudent management and limiting of exposure to operational risk. Accordingly the Committee proposed that supervisors should also apply qualitative judgment based on their assessment of adequacy of the control environment in each institution. This approach operated under Pillar 2 of the New Basel Capital Accord which recognized the supervisory review process as an integral and critical component of the capital framework. The Pillar 2 regulated a framework in which banks were required to assess the economic capital they needed to support their risks and then this assessment process was reviewed by supervisors. Where the capital assessment process was inadequate and the allocation was insufficient supervisors expected a bank to take prompt action to correct the situation. Supervisors reviewed the inputs and assumptions of internal

Table 2.1 Operational risks

Type of risk	Example	Methodology
Acute physical hazards	Tsunami, hail	Reinsurers' data + extreme value theory
Long term physical hazards	Climate change	Climate modeling + work on effects on banking system
Biorisks	SARS, animal plague	Biomedical research + quarantine expertise
Terrorism	Bombing, internet attack	Intelligence analysis
Financial markets risk	1997 Asian crisis, depression	Macroeconomic modeling, stock market analysis + extreme value theory
Real estate market risk	Home loan book loss value	Real estate market modelling
Collapse of individual major partner	Enron	Data mining on company data
Regulatory risk	Basel III, nationalization, government forces banks to pay universities for graduates	Political analysis
Legal risk	Compensation payouts for misinformed customers	Compensation law and likely changes
Managerial and strategic risk	Payout of unwanted CEO, dangerous management decision	
Internal fraud and human error	Barings rogue trader	Model pooled anonymised data, fraud detection
Robbery	Electronic access by thieves	Model pooled data, IT security expertise
Reputational risk	Run on bank, spam deceives customers	Goodwill pricing theory + marketing expertise
New technology risk	Technology allows small players to take bank market share	Futurology
Reserve risk	Reserved funds change value	
Interactions of all the above	Depression devalues real estate and reserves	Causal modeling of system interactions

methodologies for operational risk in the context of the firm wide capital allocation framework. The Committee intended to publish guidance and criteria to facilitate such an assessment process [4, 7].

Pillar 3 focused on market discipline which had the potential to reinforce capital regulation and other supervisory efforts to promote safety and soundness in banks and financial systems. The market discipline imposed strong incentives on banks to conduct their business in a safe, sound and efficient manner. It also provided a bank with an incentive to maintain a strong capital base as a cushion against potential

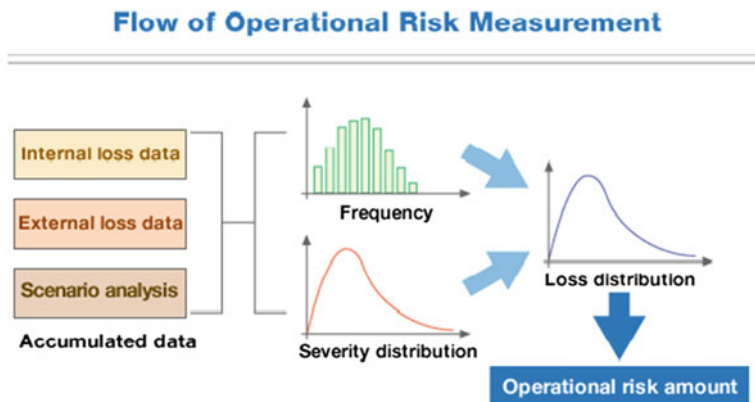


Fig. 2.1 A trivial method to measure the operational risk

future losses arising from its risk exposures. To promote market discipline the Basel Committee [4] believed that banks should publicly and in a timely fashion disclose detailed information about the process used to manage and control their operational risks and the regulatory capital allocation technique they use. More work was required to assess fully the appropriate disclosures in this area. It was possible for banks to disclose operational losses in the context of a fuller review of operational risk measurement and in the longer term such disclosures formed a part of the qualifying criteria towards internal approaches.

The framework outlined above presents three methods for calculating operational risk capital charges in a continuum of increasing sophistication and risk sensitivity. The Basel Committee intends to develop detailed criteria as guidance to banks and supervisors on whether banks qualify to use a particular approach [4]. The Committee believed that when a bank had satisfied the criteria it should be allowed to use that approach regardless of whether it has been using a simpler approach previously. Also in order to encourage innovation the Committee anticipated that a bank could have some business lines in Standardized Approach and others in Internal Measurement Approach. This will help reinforce the evolutionary nature of new framework by allowing banks to move along the continuum on a piecemeal basis. Banks could not choose to move back to simpler approaches once they have been accepted for more advanced approaches and should on a consolidated basis capture the relevant risks for each business line.

In view of substantive industry efforts to develop and implement systems for assessing, measuring and controlling operational risk the Basel Committee [4] strongly encouraged continuing dialogue and development of work among its Risk Management Group and individual firms, industry groups and others on all aspects of incorporating operational risk into the capital framework. The continued contact with industry was required to clarify further a number of issues, including those related to definitions of loss events and data collection standards. In this regard the Committee noted that by the time the New Basel Capital Accord was implemented

banks have had a meaningful opportunity to enhance internal control procedures and develop systems to support an internal measurement approach for operational risk.

With respect to data ongoing industry liaison had shown a number of important needs that should be addressed over the coming periods. The Basel Committee [4] urged the industry to work on the development of codified and centralized operational risk databases using consistent definitions of loss types, risk categories and business lines. A number of separate processes were currently in train and the Committee believed that both the supervisory and banking community would be well served by industry supported databases for pooling certain industry internal loss data. This was important not only for operational risk management purposes but also for the development of the Internal Measurement Approach. A further related data issue ensured that clean operational risk data was collected and reported. In the absence of this calibration would be difficult and capital would fail to be risk sensitive.

The Basel Committee [4] recognized the degree of cooperation that already existed on issue and welcomed the work that others have performed in conjunction with the Risk Management Group. The Committee believed that further collaboration would be essential in developing a risk sensitive framework for operational risk and for calibrating the proposed approaches. The Committee looks forward to further work with the industry to finalize a rigorous and comprehensive framework for operational risk.

The Basic Indicator Approach is the most basic approach that allocated operational risk capital using a single indicator as a proxy for an institution's overall operational risk exposure. The gross income is proposed as the indicator with each bank holding capital for operational risk equal to the amount of a fixed percentage multiplied by its individual amount of gross income. It is easy to implement and universally applicable across banks to arrive at a charge for operational risk. Its simplicity however comes at the price of only limited responsiveness to firm specific needs and characteristics. While the approach might be suitable for smaller banks with a simple range of business activities the Basel Committee expects internationally active banks and banks with significant operational risk to use a more sophisticated approach within the overall framework. For more details on this approach interested readers can refer [4, 7].

Another commonly used approach is the Standardized Approach which represents a further refinement along the evolutionary spectrum of approaches for operational risk capital. This approach differs from the Basic Indicator Approach such that a bank's activities are divided into a number of standardized business units and business lines. Thus the Standardized Approach is better able to reflect the differing risk profiles across banks as reflected by their broad business activities. However, like the Basic Indicator Approach the capital charge would continue to be standardized by the supervisor. The proposed business units and business lines of the Standardized Approach mirror those developed by an industry initiative to collect internal loss data in a consistent manner. Working with the industry, regulators specify in greater detail which business lines and activities correspond to the

categories of this framework enabling each bank to map its structure into the regulatory framework. For more details on this approach interested readers can refer [4, 7].

Within each business line regulators have specified a broad indicator that is intended to reflect the size or volume of bank’s activity in this area. The indicator is intended to serve as a rough proxy for the amount of operational risk within each of these business lines. Table 2.2 presents the business units, business lines and size or volume indicators of the Standardized Approach.

Within each business line, the capital charge is calculated by multiplying a bank’s broad financial indicator by beta factor. The beta factor serves as a rough proxy for the relationship between the industry’s operational risk loss experience for a given business line and the broad financial indicator representing the banks’ activity in that business line calibrated to a desired supervisory soundness standard. For example for the Retail Brokerage business line, the regulatory capital charge would be calculated as:

$$K_{Retail\ Brokerage} = \beta_{Retail\ Brokerage} * Gross\ Income \tag{2.1}$$

In Eq. (2.1) $K_{Retail\ Brokerage}$ is the capital requirement for the retail brokerage business line, $\beta_{Retail\ Brokerage}$ is the capital factor to be applied to the retail brokerage business line and Gross Income is the indicator for this business line. The total capital charge is calculated as the simple summation of the capital charges across each of the business lines. For more details on this approach interested readers can refer [3, 4, 7].

The primary motivation for the Standardized Approach is that most banks are in the early stages of developing firm wide data on internal loss by business lines and risk types. In addition the industry has not yet been able to show a causal relationship between risk indicators and loss experience. As a result banks that have not developed internal loss data by the time of the implementation period of the revised New Basel Capital Accord and do not meet the criteria for the Internal Measurement Approach will require a simpler approach to calculate their regulatory capital charge. In addition certain institutions may not choose to make the investment to collect internal loss data for all of their business lines, particularly those that

Table 2.2 The business units, business lines and indicators of the standardized approach

Business units	Business lines	Indicator
Investment banks	Corporate finance	Gross income
	Trading and sales	Gross income
Banks	Retail banks	Annual average assets
	Commercial banks	Annual average assets
	Payment and settlement	Annual settlement throughput
Others	Retail brokerage	Gross income
	Asset management	Total funds under management

present less material operational risk to the institution. Another important feature of the Standardized Approach is that it provides a basis for moving on a business line by business line basis towards the more sophisticated approaches and as such will help encourage the development of better risk management within banks.

Another approach worth mentioning is the Internal Measurement Approach which provides discretion to individual banks on the use of internal loss data while the method to calculate the required capital is uniformly set by supervisors. In implementing this approach supervisors would impose quantitative and qualitative standards to ensure the integrity of the measurement approach, data quality and the adequacy of the internal control environment. The Basel Committee believes that as the Internal Measurement Approach will give banks incentives to collect internal loss data step by step. This approach is positioned as a critical step along the evolutionary path that leads banks to the most sophisticated approaches. However, the Committee also recognizes that the industry is still in a stage of developing data necessary to implement this approach. Currently there is not much sufficient data at the industry level or in a sufficient range of individual institutions to calibrate the capital charge under this approach. The Committee is laying out in some detail the elements of this part of the approach and the key issues that need to be resolved. In particular, in order for this approach to be acceptable the Committee will have to be satisfied that a critical mass of institutions have been able individually and at an industry level to assemble adequate data over a number of years to make the approach workable. Under the Internal Measurement Approach a capital charge for the operational risk of a bank would be determined using the following procedures [4, 7]:

- (i) A bank's activities are categorized into a number of business lines and a broad set of operational loss types is defined and applied across business lines.
- (ii) Within each business line or loss type combination the supervisor specifies an exposure indicator (*EI*) which is a proxy for the size of each business line's operational risk exposure.
- (iii) In addition to the exposure indicator for each business line or loss type combination banks' measure based on their internal loss data, a parameter representing the probability of loss event (*PE*) as well as a parameter representing the loss given that event (*LGE*). The product of $EI * PE * LGE$ is used to calculate the expected loss (*EL*) for each business line or loss type combination.
- (iv) The supervisor supplies a factor viz. γ for each business line or loss type combination which translates the expected loss (*EL*) into a capital charge. The overall capital charge for a particular bank is the simple sum of all the resulting products. This can be expressed as:

$$required\ capital = \sum_i \sum_j [\gamma(i,j) * EI(i,j) * PE(i,j) * LGE(i,j)] \quad (2.2)$$

In Eq. (2.2) i is the business line and j is the risk type.

- (v) To facilitate the process of supervisory validation banks supply their supervisors with the individual components of the expected loss calculation i.e. EI , PE , LGE instead of just the product EL . Based on this information supervisors calculate EL and then adjust for unexpected loss through the gamma term to achieve the desired soundness standard.

The Basel Committee proposed that the business lines will be the same as those used in Standardized Approach. It is also proposed that operational risk in each business line then be divided into a number of non-overlapping and comprehensive loss types based on the industry's best current understanding of loss events. By having multiple loss types the scheme can better address differing characteristics of loss events while the number of loss types should be limited to a reasonable number to maintain the simplicity of the scheme. The Committee's provisional proposal on the grid for business lines, loss types and exposure indicators which has reflected considerable discussion with the industry [4]. While further work will be needed to specify the indicators for each risk type per business line the Committee had more confidence that the business lines and loss types are those which will form the basis of the new operational risk framework. The Committee believed that there should be continuity between approaches and that the indicators under the Standardized and Internal Measurement Approaches should be similar. The Committee therefore welcomed comment on the choice of indicators under both approaches including whether a combination of indicators might be used per business line in the Standardized Approach. The Committee also welcomed comment on the proposed loss categories.

The EI represents a proxy for the size of a particular business lines operational risk exposure. The Basel Committee proposed to standardize EI s for business lines and loss types while each bank would supply its own EI data. The supervisory prescribed EI s would allow for better comparability and consistency across banks, facilitate supervisory validation, and enhance transparency. The PE represents the probability of occurrence of loss events and loss given event (LGE) represents the proportion of transaction or exposure that would be expensed as loss given that event. PE is expressed either in number or value term as far as the definitions of EI , PE and LGE are consistent with each other. For instance PE could be expressed as the number of loss events or the number of transactions and LGE parameters can be defined as the average of (loss amount/transaction amount). While it is proposed that the definitions of PE and LGE are determined and fixed by the Basel Committee. These parameters are calculated and supplied by individual banks subject to Committee guidance to ensure the integrity of the approach. A bank would use its own historical loss and exposure data perhaps in combination with appropriate industry pooled data and public external data sources so that PE and LGE would reflect each banks own risk profile.

The term γ represents a constant that is used to transform EL into risk or a capital charge which is defined as the maximum amount of loss per a holding period within a certain confidence interval. The scale of γ will be determined and fixed by supervisors for each business line or loss type. In determining the specific figure of

γ that will be applied across banks the Basel Committee developed an industry wide operational loss distribution in consultation with the industry and used the ratio of *EL* to a high percentile of the loss distribution (99 %). The current industry practice and data availability do not permit the empirical measurement of correlations across business lines and risk types. The Basel Committee proposed a simple summation of the capital charges across business line or loss type cells. However, in calibrating the γ factors the Committee seeks to ensure that there is a systematic reduction in capital required by the Internal Measurement Approach compared to the Standardised Approach for an average portfolio of activity.

While the Basel Committee [4] believed that the definitions of business lines or loss types and parameters should be standardized at least in an early stage. The Committee also recognised such standardization may limit banks' ability to use the operational risk measures that they believe most accurately represent their own operational risk although banks could map their internal approaches into regulatory standards. As banks and supervisors gain more experience with the Internal Measurement Approach and as more data is collected the Committee examined the possibility of allowing banks greater flexibility to use their own business lines and loss types.

In order to implement the Internal Measurement Approach for regulatory capital calculation there are a number of outstanding issues to be resolved. The Committee examined the following issues in close consultation with the industry [4, 7]:

- (i) In order to use bank's internal loss data in regulatory capital calculation harmonization of what constitutes an operational risk loss event is a prerequisite for a consistent approach. Developing workable supervisory definitions in consultation with the industry of what constitutes an operational loss event for different business lines and loss types will be key to the robustness of the Internal Measurement Approach. In particular, this includes issues such as what constitutes a direct loss versus an indirect loss, over what holding period losses are considered, over what observation period historical losses are captured and the role of judgement in data collection and consolidation.
- (ii) In order to calibrate the capital calculation an industry wide distribution is used. This raises questions on data collection and consolidation and the confidence limits used. It underscores the importance of accelerating industry efforts to pool loss data under supervisory guidance on loss data collection processes.
- (iii) The historical loss observation may not always fully capture a bank's true risk profile, especially when the bank does not experience substantial loss events during the observation period. To ensure that the required capital calculated using the Internal Measurement Approach appropriately covers the potential loss including low frequency high impact events the Committee conservatively sets out elements of the scheme including factors for each business lines or risk type combination and holding period.
- (iv) As noted previously the regulatory γ which is determined based on an industry wide loss distribution will be used across banks to transform a set of

parameters such as *EI*, *PE* and *LGE* into a capital charge for each business line and risk type. However, the risk profile of a bank's loss distribution may not always be the same as that of the industry wide loss distribution. One way to address this issue is to adjust the capital charge by a risk profile index (*RPI*) which reflects the difference between the bank's specific risk profiles compared to the industry as a whole. The Committee plans to examine the extent to which individual banks risk profile will deviate significantly from that of the types of portfolios used to arrive at the regulatory term and the cost or benefits of introducing a *RPI* to adjust for such differences.

Another important methodology is the loss distribution approach (*LDA*). Under *LDA* a bank using its internal data estimates two probability distribution functions for each business line and risk type one on single event impact and the other on event frequency for the next one year. Based on the two estimated distributions the bank then computes the probability distribution function of the cumulative operational loss. The capital charge is based on the simple sum of the *VaR* for each business line and risk type. The approach adopted by the bank would be subject to supervisory criteria regarding the assumptions used. Generally the Basel Committee does not anticipate that such an approach would be available for regulatory capital purposes when the New Basel Capital Accord is introduced. However, this does not preclude the use of such an approach in the future and the Committee encourages the industry to engage in a dialogue to develop a suitable validation process for this type of approach.

In the proposed evolutionary framework of the approaches to determine capital charges for operational risk, individual banks are encouraged to move along the spectrum of available approaches as they develop more sophisticated operational risk measurement systems and practices. Additional standards are intended to ensure the integrity of the measurement approach, data quality and the risk management control environment. The minimum standards that the Basel Committee sees as essential for recognizing a bank to be eligible for each stage are as follows [4, 7]:

- (i) The Basic Indicator Approach is intended to be applicable by any bank regardless of its complexity or sophistication. As such no criteria for use apply. Nevertheless, banks using this approach will be urged to comply with the forthcoming Committee guidance on Operational Risk Sound Practices which will also serve as guidance to supervisors under Pillar 2.
- (ii) As well as meeting the Committees Operational Risk Sound Practices banks will have to meet the following standards to be eligible for the Standardized Approach:
 - (a) Banks must meet a series of qualitative standards including the existence of an independent risk control and audit function, effective use of risk reporting systems, active involvement of board of directors and senior management and appropriate documentation of risk management systems.

- (b) Banks must establish an independent operational risk management and control process which covers the design, implementation and review of its operational risk measurement methodology. Responsibilities include establishing the framework for the measurement of operational risk and control over the construction of the operational risk methodology and key inputs.
 - (c) Banks internal audit groups must conduct regular reviews of the operational risk management process and measurement methodology.
 - (d) Banks must have appropriate risk reporting systems to generate data used in the calculation of a capital charge and the ability to construct management reporting based on the results.
 - (e) Banks must begin to systematically track relevant operational risk data by business line across the firm. It should be noted that the ability to monitor loss events and effectively gather loss data is a basic step for operational risk measurement and management and is a pre-requisite for movement to the more advanced regulatory approach.
 - (f) Banks will have to develop specific documented criteria for mapping current business lines and activities into the standardized framework. In addition, a bank should regularly review the framework and adjust for new or changing business activities and risks as appropriate.
- (iii) In this approach business lines, risk types and exposure indicators are standardized by supervisors and individual banks are able to use internal loss data. In addition to the standards required for banks using the Standardized Approach and banks should meet the following standards to use the Internal Measurement Approach:
- (a) Accuracy of loss data and confidence in the results of calculations using that data including *PE* and *LGE* have to be established through use tests. Banks must use the collected data and the resulting measures for risk reporting, management reporting, internal capital allocation purposes, risk analysis etc. Banks that do not fully integrate an internal measurement methodology into their day-to-day activities and major business decisions should not qualify for this approach.
 - (b) Banks must develop sound internal loss reporting practices supported by an infrastructure of loss database systems that are consistent with the scope of operational losses defined by supervisors and the banking industry.
 - (c) Banks must have an operational risk measurement methodology, knowledgeable staff and an appropriate systems infrastructure capable of identifying and gathering comprehensive operational risk loss data necessary to create a loss database and calculate appropriate *PEs* and *LGEs*. Systems should be able to gather data from all appropriate sub-systems and geographic locations. Missing data from various systems, groups or locations should be explicitly identified and tracked.
 - (d) Banks need an operational risk loss database extending back for a number of years to be set by the Basel Committee for significant business lines.

Additionally banks must develop specific criteria for assigning loss data to a particular business line and risk types.

- (e) Banks must have in place a sound process to identify in a consistent manner over time the events used to construct a loss database and to be able to identify which historical loss experiences are appropriate for the institution and are representative of their current and future business activities. This entails developing and defining loss data criteria in terms of the type of loss data and the severity of the loss data that goes beyond the general supervisory definition and specifications.
- (f) Banks must develop rigorous conditions under which internal loss data would be supplemented with external data as well as a process for ensuring the relevance of this data for their business environment. Sound practices need to be identified surrounding the methodology and process of scaling public external loss data or pooled internal loss data from other sources. These conditions and practices should be re-visited on a regular basis must be clearly documented and should be subject to independent review.
- (g) Sources of external data must be reviewed regularly to ensure the accuracy and applicability of the loss data. Banks must review and understand the assumptions used in the collection and assignment of loss events and resultant loss statistics.
- (h) Banks must regularly conduct validation of their loss rates, risk indicators and size estimations in order to ensure the proper inputs to the regulatory capital charge.
- (i) Banks must adhere to rigorous processes in estimating parameters such as *EI*, *PE* and *LGE*.
- (j) As part of the validation process, scenario analysis and stress testing would help banks in their ability to gauge if the operational environment is accurately reflected in data aggregation and parameter estimates. A process would need to be developed to identify and incorporate plausible historically large or significant events into assessments of operational risk exposure which may fall outside the observation period. These processes should be clearly documented and be specific enough for independent review and verification. Such analysis would also assist in gauging the appropriateness of certain judgements or over-rides in the data collection process.
- (k) Bank management should incorporate experience and judgement into an analysis of the loss data and the resulting *PEs* and *LGEs*. Banks have to clearly identify the exceptional situations under which judgement or over-rides may be used to what extent they are to be used and who is authorized to make such decisions. The conditions under which these over-rides may be made and detailed records of changes should be clearly documented and subject to independent review.
- (l) Supervisors will need to examine the data collection, measurement and validation process and assess the appropriateness of the operational risk control environment of the institution.

Outsourcing by banks is another activity which is increasing both in terms of volume of business involved and the range of functions outsourced. There are sound business reasons why a bank may outsource functions. These include a reduction in both fixed and current expenditure and compensation for a lack of expertise or resources. The Basel Committee [4] believes that banks engaged in outsourcing should aim to ensure that a clean break in their outsourced activities is established if there is to be a reduction in operational risk capital mainly through arranging robust legal agreements with outside service providers through a Service Level Agreement. Banks should also develop appropriate policies and controls to assess quality and stability of outside service providers. Where outsourcing is conducted between banks it is the entity that bears the ultimate responsibility for operational loss that should hold the capital. In order to benefit from a reduction in regulatory capital the bank conducting outsourcing need to demonstrate supervisor's satisfaction that effective risk transfer has occurred.

In an effort to encourage better risk management practices the Basel Committee is keenly interested in efforts by institutions to better mitigate and manage operational risk. Such controls or programs have the potential to reduce the exposure, frequency or severity of an event. Due to the crucial role these techniques can play in managing risk exposures. The Committee intends to work with the industry on risk mitigation concepts. However, careful consideration needs to be given to whether the control is truly reducing risk or merely transferring exposure from the operational risk area to another business sector.

One growing risk mitigation technique is the use of insurance to cover certain operational risk exposures. During discussion with the industry the Basel Committee [4] found that firms were using or were considering using insurance policies to mitigate operational risk. These include a number of traditional insurance products such as bankers' blanket bonds and professional liability insurance. Specifically, insurance could be used to externalize the risk of potentially low frequency and high severity losses such as errors and omissions including processing losses, physical loss of securities and fraud. The Committee agrees that in principle such mitigation should be reflected in the capital requirement for operational risk. Moreover banks that use insurance should recognize that they might be replacing operational risk with a counterparty risk. There are also other questions relating to liquidity i.e. the speed of insurance payouts, loss adjustment and voidability, limits in the product range, the inclusion of insurance payouts in internal loss data and moral hazard. The Committee welcomes further industry analysis on the robustness of such mitigation techniques in the context of a discussion about regulatory capital requirements. The Risk Management Group continues to develop its existing dialogue with the industry on this topic.

It is widely agreed that there are unusual difficulties in the way of bank's quantifying its operational risks adequately or even of getting a ballpark figure for many of them. Availability of data is a major challenge. Individual banks rarely report internal frauds unless they are catastrophic. An individual bank has thus very

little data on past events that it fears may impact it severely in the future. It is not usual for individual banks to hold data on public events like tsunamis as banks are not in environmental modeling business. Therefore, there are opportunities for bank regulators to encourage a public centre to warehouse shared and if necessary anonymised data and to broker the expertise of environmental and economic modelers on risks from external sources that can be studied with publicly available data.

It is generally agreed also that the diversity of operational risks creates methodological difficulties both in quantifying individual risks and in estimating their interactions. Given that the downside tails of distribution of events are crucial and that there is little data on tail events, it is necessary to avoid assuming that the events follow a standard distribution such as normal distribution even if that fits well the middle range of events. Basel II mandates usage of extreme value theory, the statistical methodology for extrapolation of tails of distributions beyond the range of existing data. The paucity of data on operational risks also means that it is essential to combine what data is there with experts' opinion. The elicitation and calibration of expert opinion by small data sets is itself a difficult theoretical area.

2.3 Regulatory Framework

Operational risk has been an actively sought after topic in financial institutions, banks, insurance companies etc. [3]. In the past few decades these institutions have experienced more than 100 operational loss events exceeding over hundreds of million dollars. Some noteworthy examples include \$691 million rogue trading loss at Allfirst Financial, \$484 million settlement due to misleading sales practices at Household Finance and estimated \$140 million loss stemming from the 9/11 attack at the Bank of New York. Recent settlements related to questionable business practices have further heightened interest in the management of operational risk at financial institutions. These issues are handled through certain regulatory frameworks as suggested by the recommendations of Basel Committee for banks [4, 7]. The Basel Committee provides a forum for regular cooperation on banking supervisory matters. Its objective is to enhance understanding of key supervisory issues and improve the quality of banking supervision worldwide.

The most elementary form of Basel viz. Basel I capital accord was created on 1988 [14] whose general purpose was to: (a) strengthen the stability of international banking system and (b) set up a fair and a consistent international banking system in order to decrease competitive inequality among international banks. The basis of capital in Basel I is categorized in two tiers viz. (a) tier I (core capital) which includes stock issues and declared reserves such as loan loss reserves set aside to cushion future losses or for smoothing income variations and (b) tier II (supplementary capital) which includes all other capital such as gains on investment assets,

long term debt with maturity greater than five years and hidden reserves i.e. excess allowance for losses on loans and leases. According to Basel I the total capital should represent at least 80 % of the bank's credit risk which can be: (a) on-balance sheet risk like risks associated with cash and gold held with bank, government bonds and corporate bonds (b) market risk including interest rates, foreign exchange, equity derivatives and commodities and (c) non trading off-balance sheet risk like forward purchase of assets or transaction related debt assets. However, Basel I suffered from certain limitations such as: (a) limited differentiation of credit risk (b) static measure of default risk (c) no recognition of term structure of credit risk (d) simplified calculation of potential future counter party risk and (e) lack of recognition of portfolio diversification effects.

The limitations of Basel I are effectively handled by Basel II [7] which is based on three pillars viz. (a) minimum capital where banks must hold capital against 8 % of their assets after adjusting the risk factors (b) supervisory review whereby national regulators ensure their home country banks are adhering the rules and (c) market discipline based on enhanced disclosure of risk. In Basel II risk was categorized as credit risk, market risk and operational risk. The credit risk has three approaches such as standardization, foundation internal ratings and advanced internal ratings. Basel II impact on banking sector led to huge capital requirement, wider market domain, a large array of products and customers. Some important advantages of Basel II are: (a) the discrepancy between economic capital and regulatory capital is reduced significantly due to which the regulatory requirements rely on bank's own risk methods (b) Basel II are more risk sensitive and (c) it has wider recognition of credit risk mitigation. Basel II suffers from limitations such as: (a) too much regulatory compliance (b) over focusing on credit risk (c) the new accord is complex and therefore demanding for supervisors and unsophisticated banks and (d) strong risk identification in the new accord can adversely affect the borrowing position of risky borrowers.

The stated limitations of Basel II are taken care of by Basel III in 2010 [13] which is based on norms such as: (a) improving the banking sector's ability to absorb shocks arising from financial and economic stress (b) improve risk management and governance and (c) strengthen banks' transparency and disclosures. The structure of Basel III accord includes: (a) minimum regulatory capital requirements based on risk weighted assets where maintained capital is calculated through credit, market and operational risks (b) supervisory review process which specifies regulation of tools and frameworks for dealing with peripheral risks that bank face and (c) market discipline which increases the disclosures that banks must provide to increase the transparency of banks. Some major changes of Basel III are: (a) better capital quality (b) capital conservation buffer (c) counter cyclical buffer (d) minimum common equity and tier I capital requirements (e) leveraging ratios (f) liquidity ratios and (g) systematically important financial institutions. The Basel III has major impact on: (a) on banks (b) on financial stability and (c) on investors.

2.4 Operational Risk Data: Internal and External

The data may be collected from different sources for analysing operational risk [3]. The two commonly used sources for data collection are: (a) internal source of data mainly comes from inside the organization which is provided by the management after verifying the actual operational losses incurred while running the business and (b) external source of data is generally provided by vendors who gather the data on behalf of the organization after surveying the operational losses incurred. In recent times the data is often provided by the vendors as it eliminates biasedness in the data collection process. The vendors collect data from public sources [8] such as news reports, court filings, securities and exchange (SEC) filings etc.

One such instance of data collection was done in May 2001 by the Basel Committee on banking supervision [14] which launched a survey of banks operational risk data. In a repeat of this exercise, the committee collected detailed data from the banking sector on operational risk for the current financial year. The data collection exercise included information on banks operational risk losses and various exposure indicators. This enabled the committee to further refine the calibration of the operational risk charge proposed for the new Basel accord. The committee provided banks with spreadsheets outlining the operational risk information requested as well as detailed instructions to assist banks in completing the survey. Banks were asked to complete and return the survey via national supervisors by 31st August 2002. All the data received were treated with complete confidentiality. The Committee then provided feedback to the industry on the results of the survey. However, this was done on a basis that avoids any disclosure of individual bank data.

The raw data collected is basically unstructured and impure in nature [8]. The data is pre-processed through filtering, normalization etc. [3] in order to remove the inherent impurities in the data. This pre-processed data is in the form of a database and is suitable for further experimentation and analysis [3]. However, the absence of reliable internal operational loss data has impeded organization's progress in measuring and managing operational risk. Without such data most firms have not been able to quantify operational risk correctly.

2.5 Quantifying Operational Risk

After the data is available in a reliable form it is subjected to quantification. Measuring operational risk from publicly available data poses several challenges, the most significant being that not all operational risk losses are correctly reported. One can also expect a positive relationship to exist between the loss amount and the probability that the loss is reported. If this relationship does exist then the data are not a random sample from the population of all operational losses but they are biased sample containing disproportionate number of losses. Standard statistical

inferences based on such samples can yield biased parameter estimates [11]. The disproportionate number of losses may lead to an estimate that overstates organization's exposure to operational risk.

Another way of describing this sampling problem is to say that an operational loss is publicly reported only if it exceeds some unobserved truncation point. Because the truncation point is unobserved it is a random variable and the resulting statistical framework is known as a random or stochastic truncation model. Techniques for analysing randomly truncated data are reviewed in [3]. In related work [6] proposed a random truncation framework to model operational loss data and provide initial empirical results suggesting the feasibility of approach. Here we discuss one such approach to quantify operational risk [6].

Let x and y be random variables whose joint distribution is $j(x, y)$. The variable x is randomly truncated if it is observed only when it exceeds the unobserved truncation point y . If x and y are statistically independent then the joint density $j(x, y)$ is equal to the product of marginal densities $f(x)$ and $g(y)$. The condition on x is and this is expressed as [3, 11]:

$$\begin{aligned} j(x, y|x > y) &= f(x)g(x)/\Pr(x > y) \\ j(x, y|x > y) &= f(x)g(x)/\iint_{-\infty}^x f(x)g(x)dxdy \\ j(x, y|x > y) &= f(x)g(x)/\int f(x)G(x)dx \end{aligned} \quad (2.3)$$

In Eq. (2.3) $G(\cdot)$ denotes the cumulative distribution function of y . Integrating the unobserved variable y yields the marginal with respect to x [3, 11]:

$$f(x|x > y) = f(x)G(x)/\int f(x)G(x)dx \quad (2.4)$$

The above expression is the distribution of observed values of x and forms the basis for the estimation techniques. The experiment data generally consists of a series of operational losses exceeding millions of dollars in nominal value. Extreme value theory suggests that the distribution of losses exceeding such high threshold can be approximated by a generalized Pareto distribution. If X be a vector of operational loss amounts and $x = X - u$, where u is a threshold value. The Pickands-Balkema-de Haan Theorem discussed in the next Chapter [3], [5] implies that the limiting distribution of x as u tends to infinity is given by:

$$GPD_{\xi, b}(x) = \begin{cases} 1 - (1 + \xi x/b)^{-1/\xi} & \xi > 0 \\ 1 - \exp(-x/b) & \xi = 0 \end{cases} \quad (2.5)$$

In Eq. (2.5) which of the two cases holds depends on the underlying loss distribution. If it belongs to a heavy tailed class of distributions such as burr, cauchy, log, gamma, pareto etc. then convergence is the GPD with $\xi > 0$. If it

belongs to light tailed class such as gamma, lognormal, normal, Weibull etc. then convergence is to the exponential distribution ($\zeta = 0$). We assume that the distribution of operational losses belongs to heavy tailed class of distributions which implies that the distribution of log losses belongs to light tailed class. The exponential distribution has only one parameter that makes it attractive for current application. We thus model natural logarithm of operational losses and set $f(x)$ in Eq. (2.4) as:

$$f(x) = \exp(-x/b)/b \quad (2.6)$$

In Eq. (2.6) x denotes the log of the reported loss amount X minus the log of the million dollar threshold. The above method for modeling the distribution of losses is referred to as the peaks over threshold approach and is discussed in [3].

To model the distribution of the truncation point y we assume that whether or not a loss is captured in public disclosures depends on many random factors. In this case, a central limit argument suggests that y is normally distributed. However, we find that the normality assumption results in frequent non-convergence of the numerical maximum likelihood iterations. Alternatively we can assume that the truncation point has a logistic distribution [3]:

$$G(x) = 1/[1 + \exp(-\beta(x - \tau))] \quad (2.7)$$

The logistic distribution closely approximates the normal distribution but its fatter tails can make it more suitable than the normal for certain applications. The logistic distribution is more suitable for the current application as well so that convergence issues are quite rare under this assumption. The logistic distribution has two parameters viz. (a) the location parameter τ that indicates the (log) loss amount with a 50 % chance of being reported and (b) a scale parameter β that regulates how quickly the probability of reporting increases or decreases as the loss amount increases or decreases.

The data consist of $\{x, u\}$ where x denotes the natural logarithm of the reported loss amount minus the natural logarithm of the million dollar threshold value and u is the million dollar threshold value below which losses are not reported and adjusted for inflation. The likelihood equation is [3, 11]:

$$L(b, \beta, \tau | X, u) = \prod_{i=1}^n \left[f(x_i | b) G(x_i | \beta, \tau) / \int_{u(i)}^{\infty} f(x | b) G(x | \beta, \tau) dx \right] \quad (2.8)$$

For more details on quantification on operational risk interested readers can refer [3].

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